# IEC TS 62607-12-3

Edition 1.0 2026-06

# TECHNICAL SPECIFICATION

## Nanomanufacturing - Key control characteristics -
## Part 12-3: 2D material-related products - Schottky barrier heights of 2D material-based field-effect transistors: temperature-dependent current-voltage measurements



IEC TS 62607-12-3:2026-06(en)

ICS 07.120

ISBN 978-2-8327-1283-2

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

**About the IEC**
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - webstore.iec.ch/advsearchform**
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - webstore.iec.ch/justpublished**
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - webstore.iec.ch/csc**
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

**IEC Products & Services Portal - products.iec.ch**
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - www.electropedia.org**
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



**Warning! Make sure that you obtained this publication from an authorized distributor.**

# CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

# Nanomanufacturing - Key control characteristics - Part 12-3: 2D material-related products - Schottky barrier heights of 2D material-based field-effect transistors: temperature-dependent current–voltage measurements

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.



IEC TS 62607-12-3 has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

| Draft | Report on voting |
|---|---|
| 113/967/DTS | 113/976/RVDTS |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62607 series, published under the general title *Nanomanufacturing - Key control characteristics*, can be found on the IEC website.

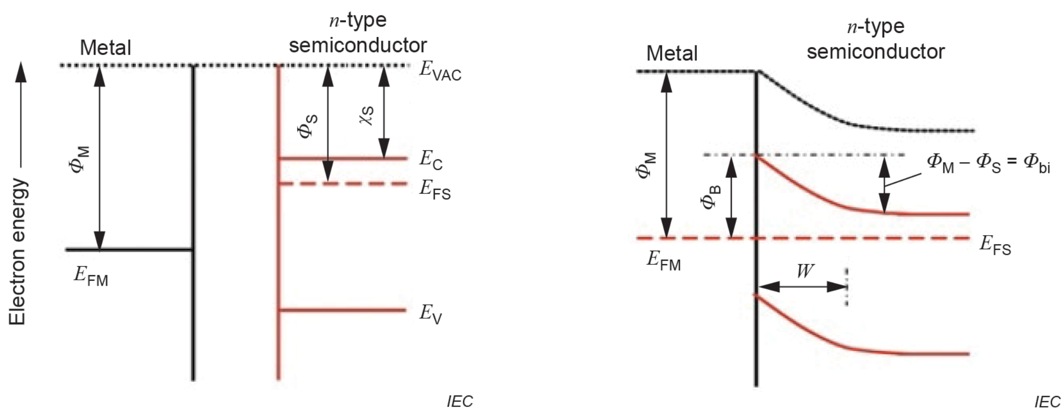
The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

# INTRODUCTION

Atomically thin two-dimensional (2D) materials are expected to be used for future electrical sub-systems or electronic device applications.

The Schottky barrier refers to a potential energy barrier that forms at the interface between a metal and a semiconductor or other material. See Figure 1.




**a) Electron energy before contact** **b) Electron energy after contact**

**Key**

| | |
|---|---|
| $\Phi_M$ | work function of a metal |
| $\Phi_S$ | work function of a semiconductor |
| $\Phi_B$ | Schottky barrier height formed at the metal-semiconductor junction |
| $W$ | depletion width in a semiconductor |
| $\Phi_{bi}$ | built-in potential induced in the depletion region of a semiconductor |
| $E_{VAC}$ | energy level of vacuum |
| $E_{FM}$ and $E_{FS}$ | Fermi energy levels of a metal and a semiconductor, respectively |
| $E_C$ and $E_V$ | energy levels of conduction band minimum and valence band maximum, respectively |
| $\chi_S$ | electron affinity of a semiconductor |



**Figure 1 – Energy band diagram of a metal–semiconductor junction**

In electronic devices, this barrier can influence the flow of current across the interface, as it can prevent or allow the movement of electrons depending on the direction of the voltage applied. The Schottky barrier height (SBH) is expressed in unit of Joule (J) or electron volt (eV); however, electron volt is more widely used in the electronic device community.

Specifically, when a metal is placed in contact with a semiconductor, the difference in work function between the two materials can lead to the formation of depletion of free carriers near the interface. The depletion region as shown in Figure 1 is dependent on SBH and doping concentration, and it affects the flow of electrons.

The magnitude of the SBH depends on a number of factors, including the choice of materials, the doping concentration of the semiconductor, and the voltages applied to the device. In some cases, the Schottky barrier can be deliberately engineered to control the flow of current in electronic devices, such as in Schottky diodes, which are commonly used in a range of electronic applications, including power supplies, radio frequency (RF) circuits, and digital logic circuits. Examples of Schottky devices include Schottky diodes, Schottky transistors, and Schottky barrier photodiodes.

As for conventional semiconductor devices, several methods have been used to determine SBH, e.g. temperature-dependent current–voltage ($I$–$V$) measurement, capacitance–voltage ($C$–$V$) measurement, and photocurrent measurement. [1][1]

However, it is difficult to measure SBH of 2D materials by using $C$–$V$ methods because their ultra-thinness and van der Waals (vdW) gap formed at the metal–2D semiconductor interfaces give rise to unreliable results arising from various parasitic capacitance components. It is also difficult to measure SBH of 2D materials by using photocurrent which is dependent on internal photo-emission because their ultra-thinness gives rise to weak optoelectronic intensity and vdW gap formed at the metal-semiconductor interfaces gives rise to noisy photocurrent signal.

Therefore, the current–voltage ($I$–$V$) measurement as the fundamental electrical characterization technique has been predominantly utilized to measure SBH in 2D materials-based electronic devices. Especially, $I$–$V$ transfer curves obtained from 2D material-based field-effect transistors (FETs) at various temperatures have been used to extract SBH, as shown in Figure 2. That is, SBH can be determined by measuring only current arising from thermionic emission at elevated temperatures at the flat-band condition without current arising from field emission which is commonly described as tunnelling.



[1] Numbers in square brackets refer to the Bibliography.